

CHEMICAL ENGINEERING DESIGN & SAFETY CHE 4253

Prof. Miguel Bagajewicz

Distillation/Absorption Systems

DISTILLATION/ABSORPTION COLUMN DESIGN



1800 or earlier

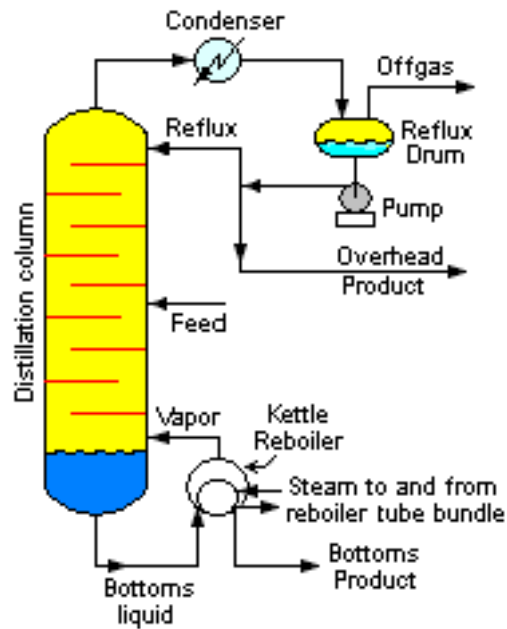


Now

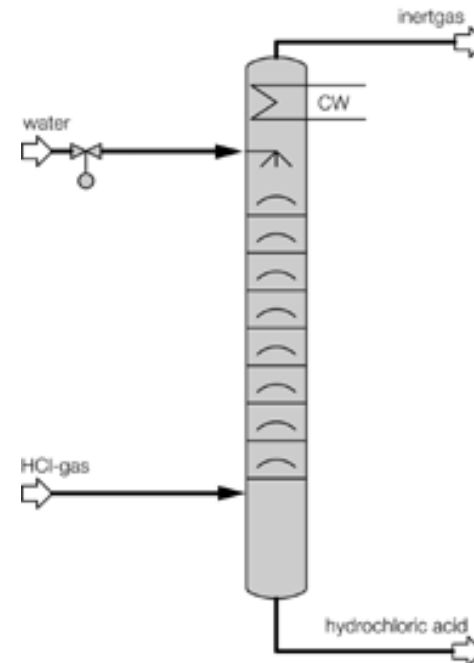


DISTILLATION/ABSORPTION COLUMN DESIGN

Distillation

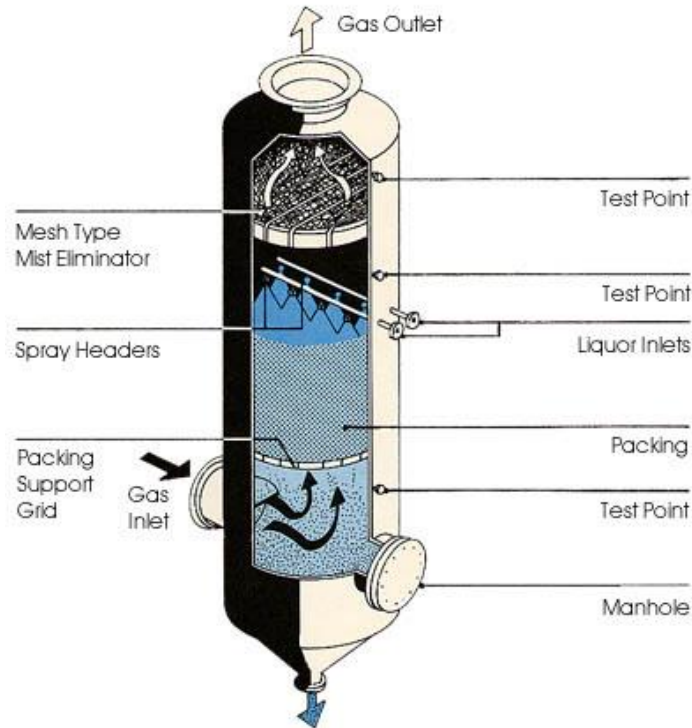


Absorption

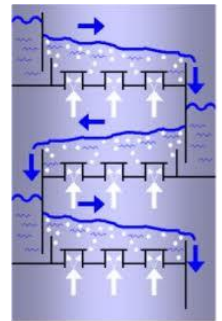
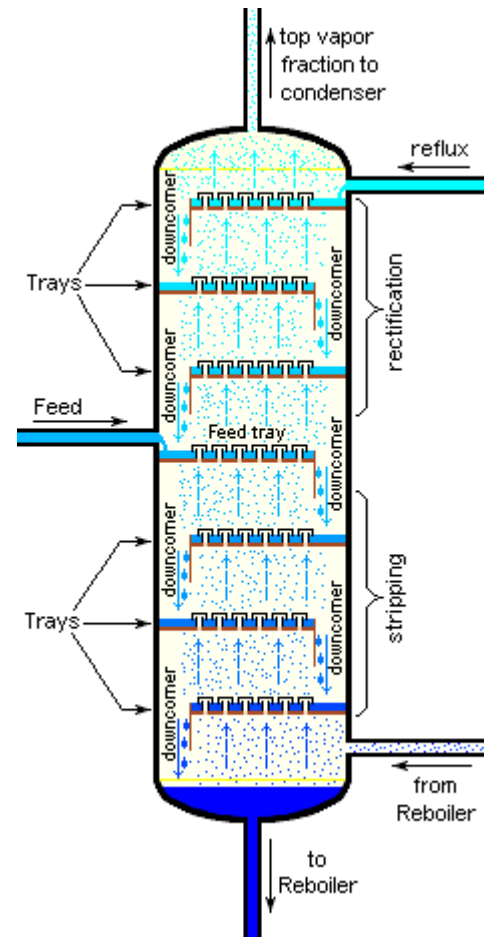


DISTILLATION/ABSORPTION COLUMN DESIGN

Packed Tower

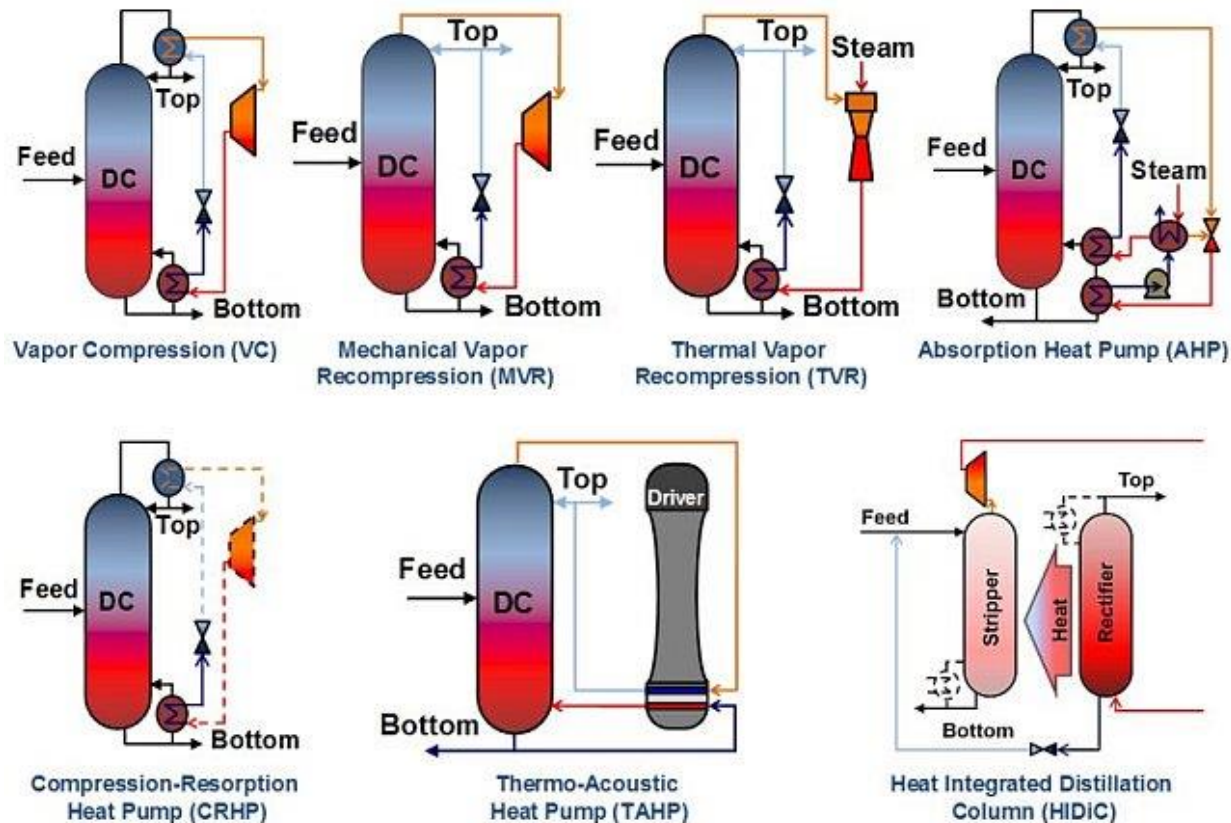


Tray tower



DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Unconventional Columns



DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns

Heat Integrated Distillation Columns (HIDiC)

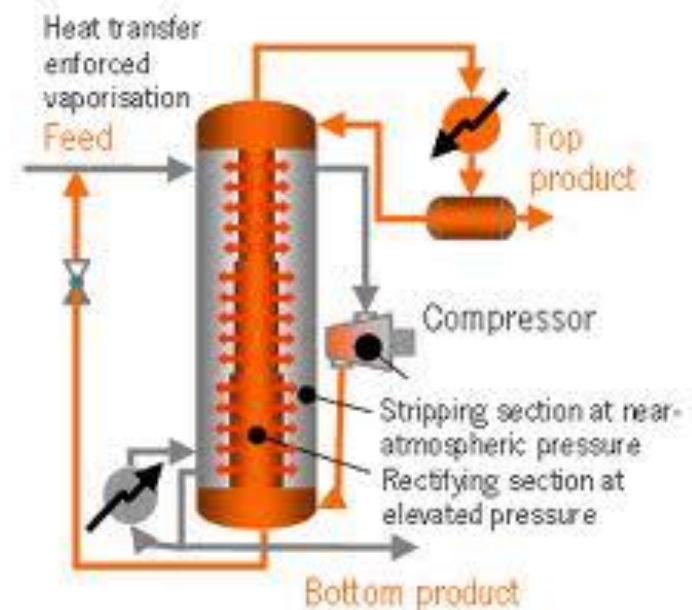
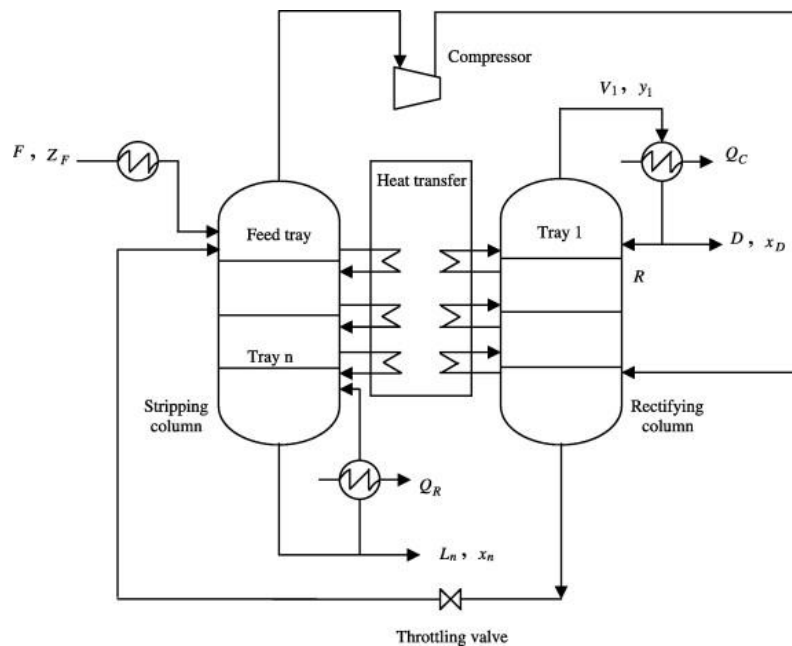


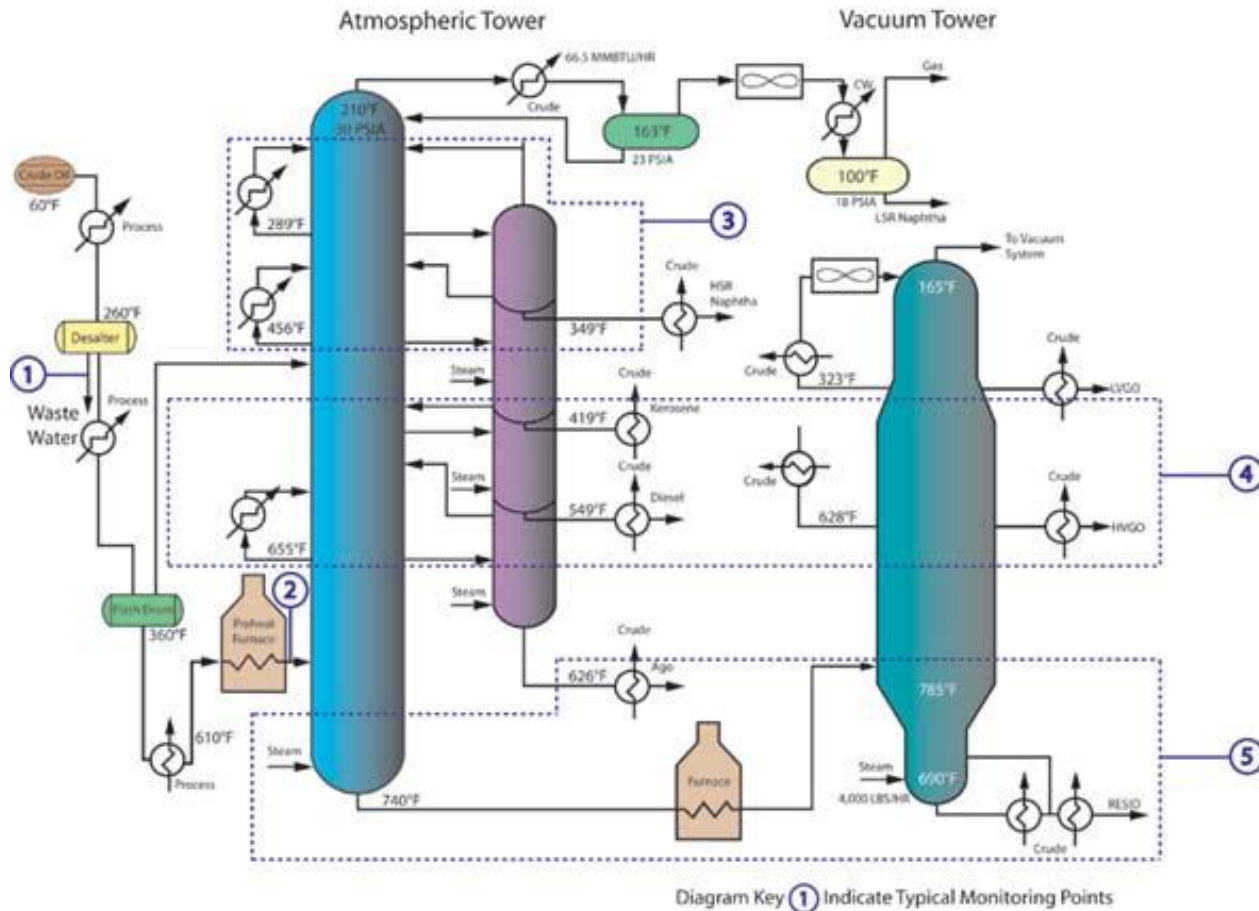
Fig. 1 HIDiC concentric tube column



DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns

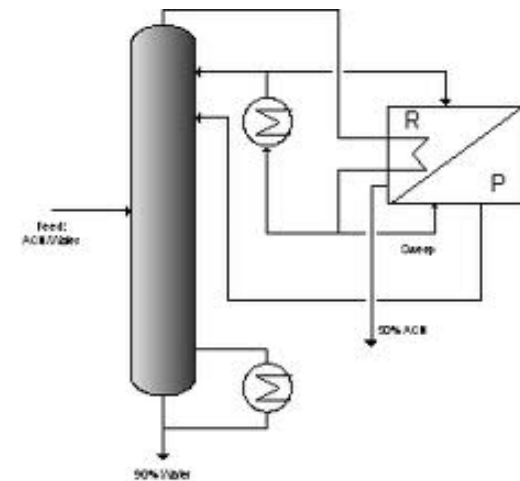
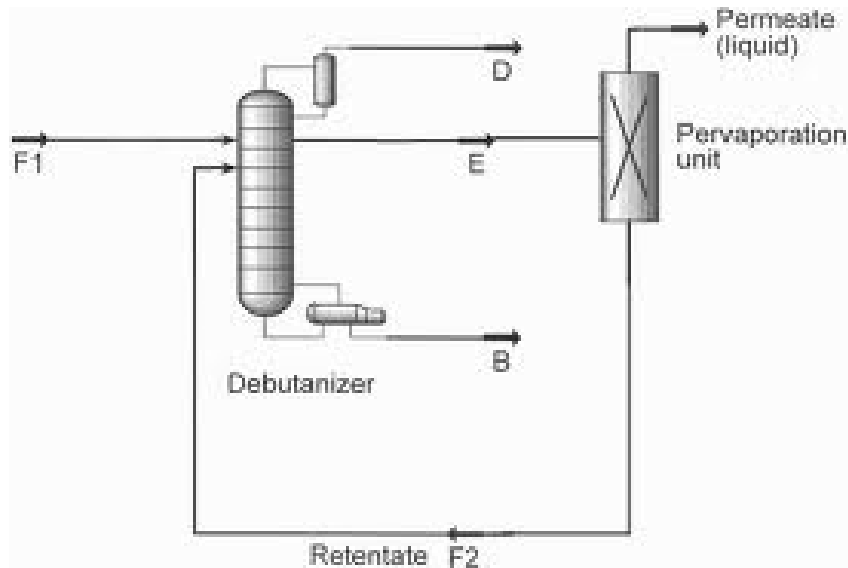
Petroleum Fractionation



DISTILLATION/ABSORPTION COLUMN DESIGN

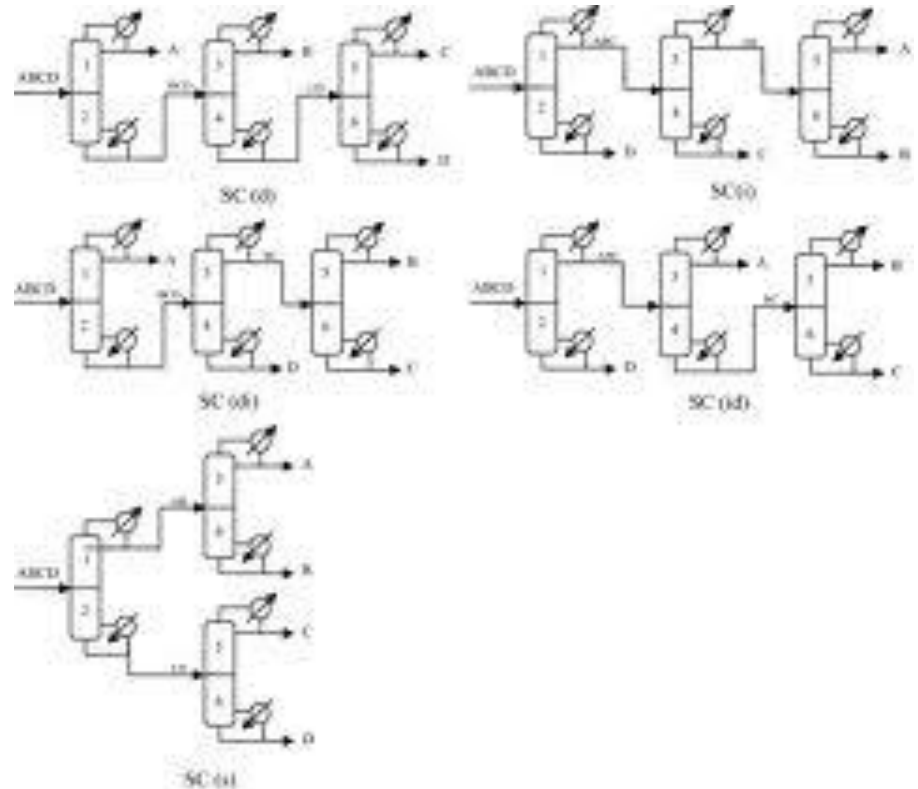
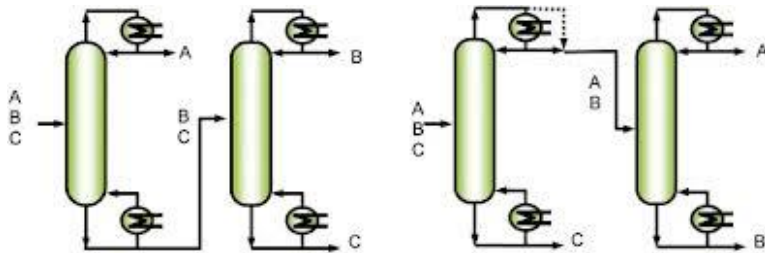
Complex Columns

Pervaporation distillation



DISTILLATION/ABSORPTION COLUMN DESIGN

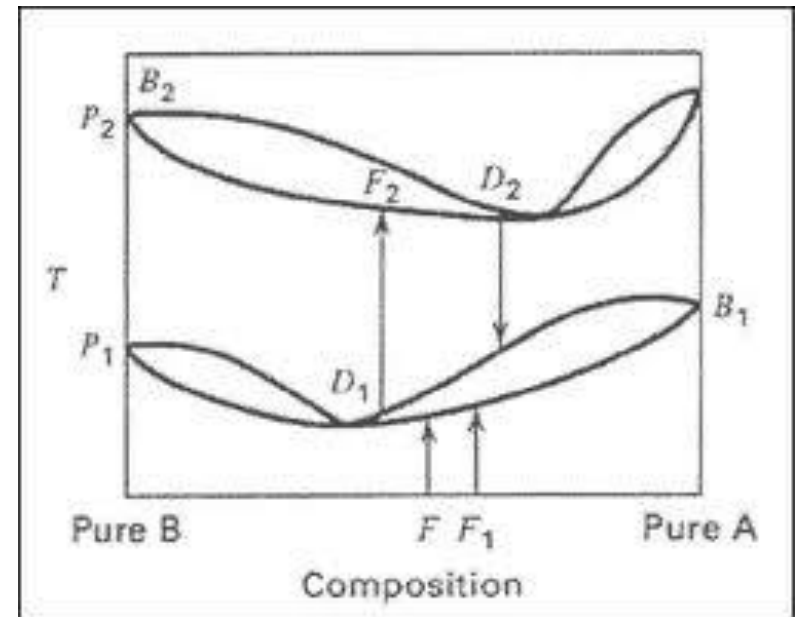
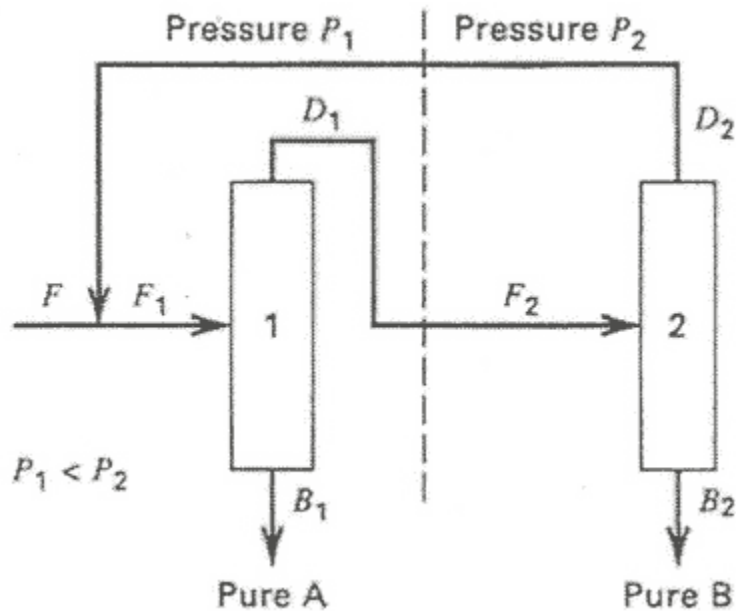
Simple Sequences



DISTILLATION/ABSORPTION COLUMN DESIGN

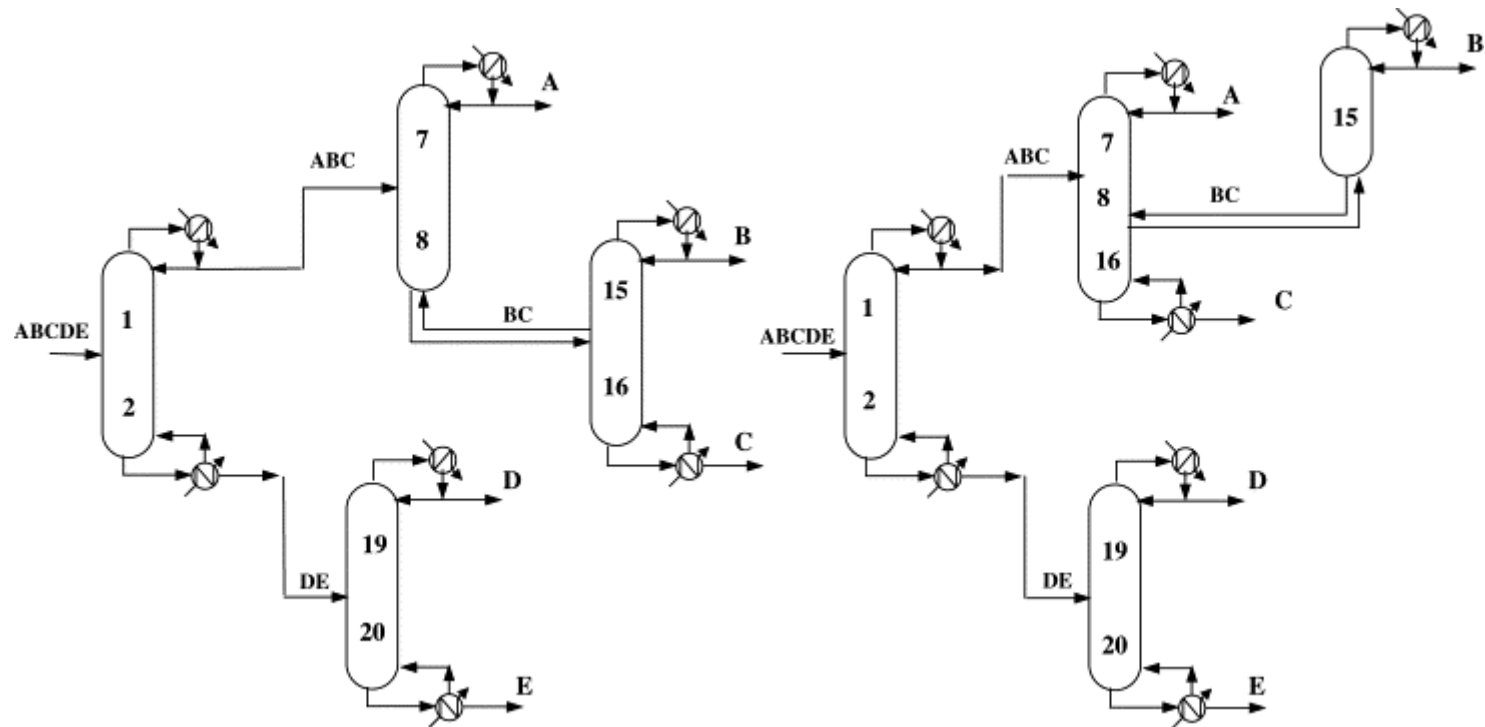
Complex Columns

Pressure Swing Distillation



DISTILLATION/ABSORPTION COLUMN DESIGN

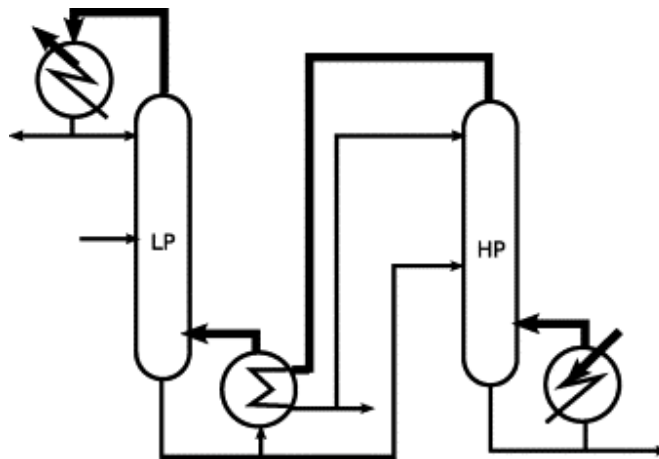
Non-Simple Sequences



DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns

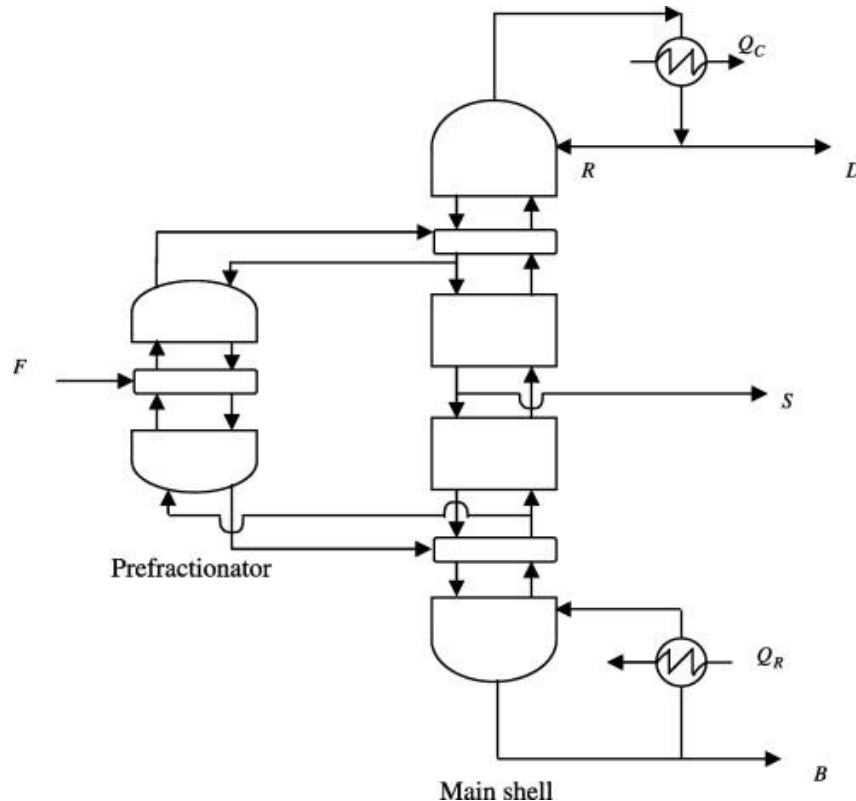
Double Effect



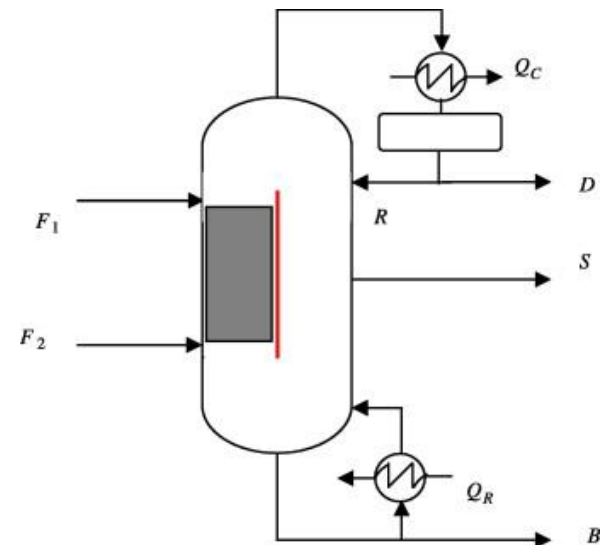
DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns

Petlyuk Columns (circa 1960)



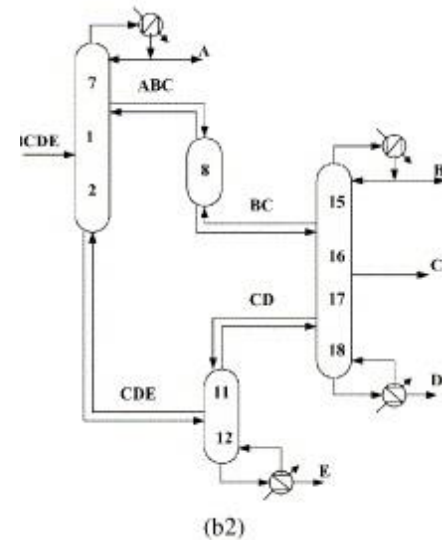
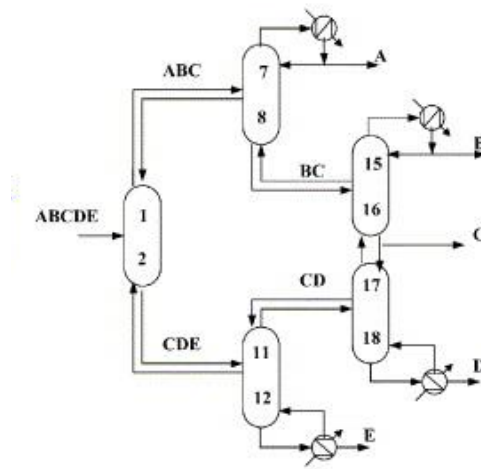
Divided wall column



DISTILLATION/ABSORPTION COLUMN DESIGN

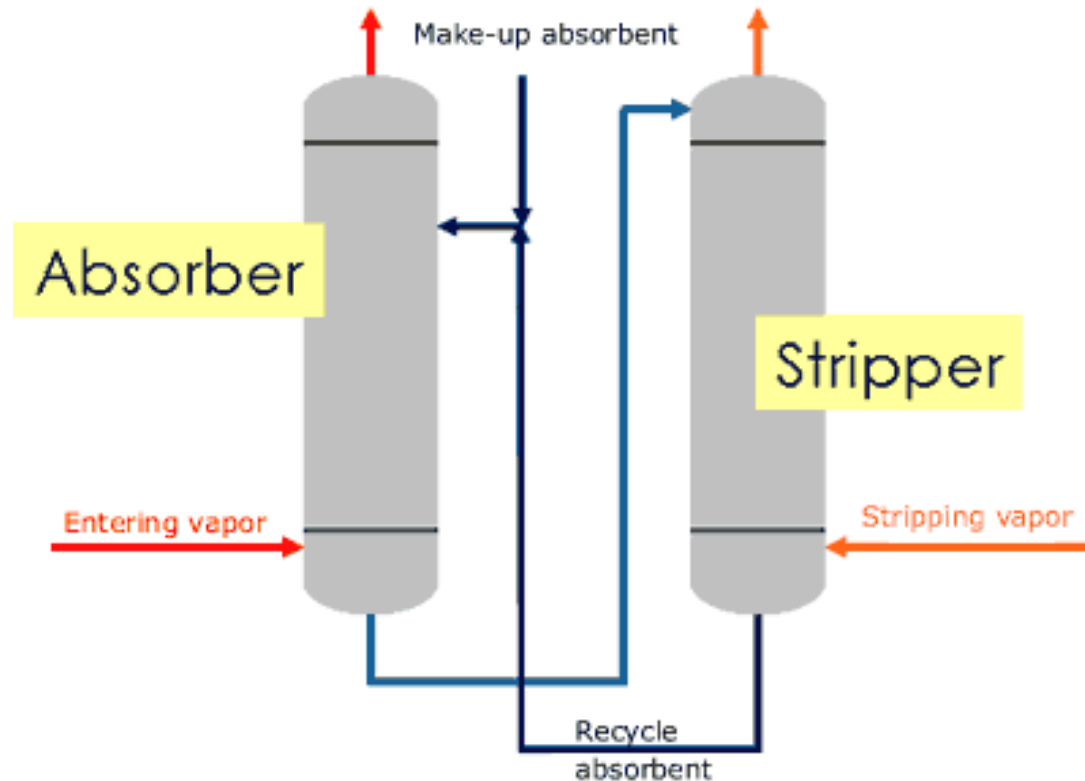
Complex Columns Multicomponent cases

Complex Sequences



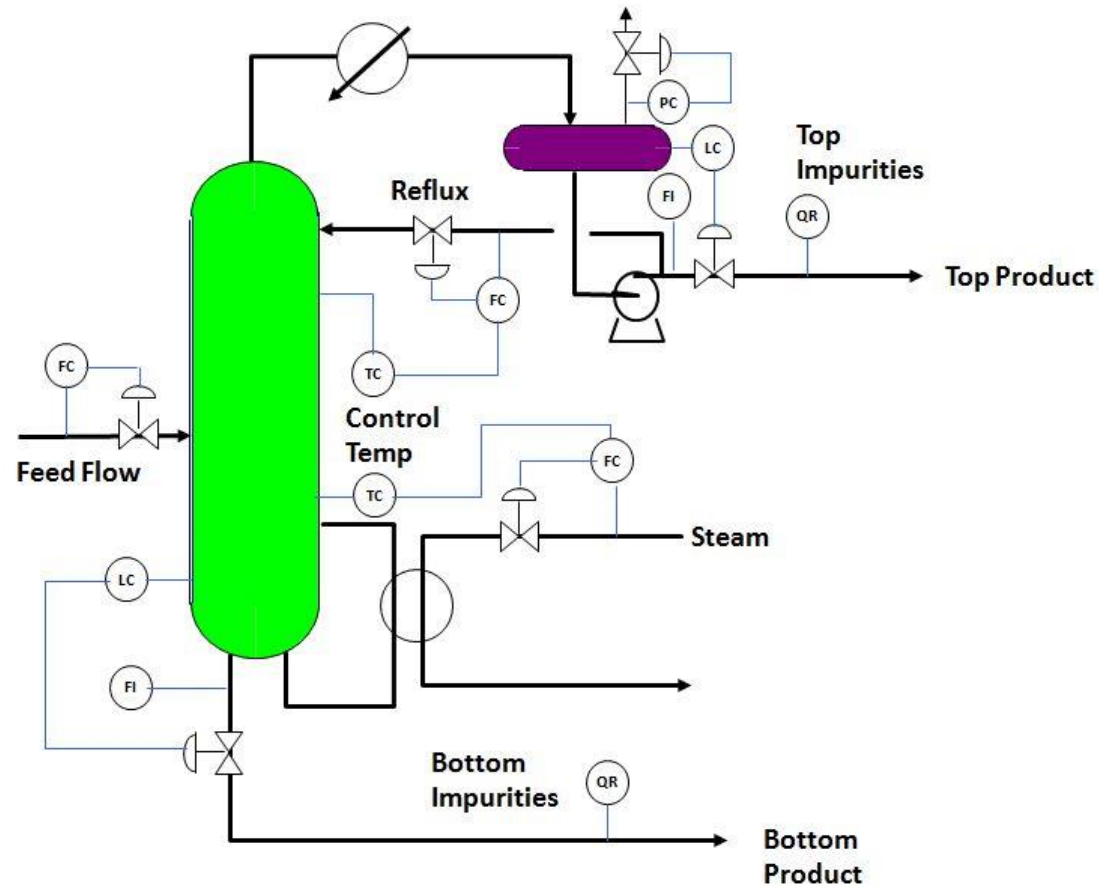
DISTILLATION/ABSORPTION COLUMN DESIGN

Absorber/stripper typical arrangement.



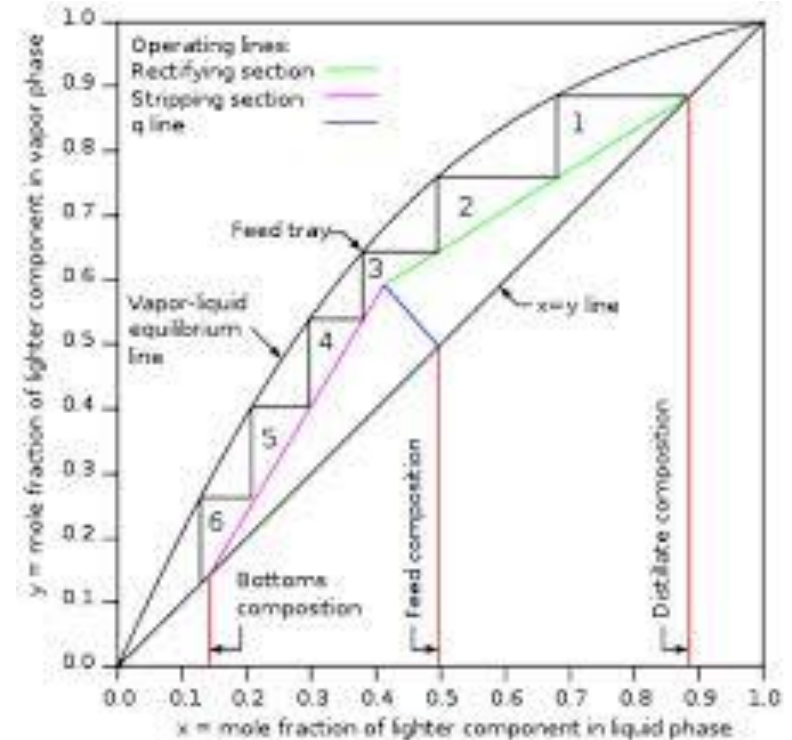
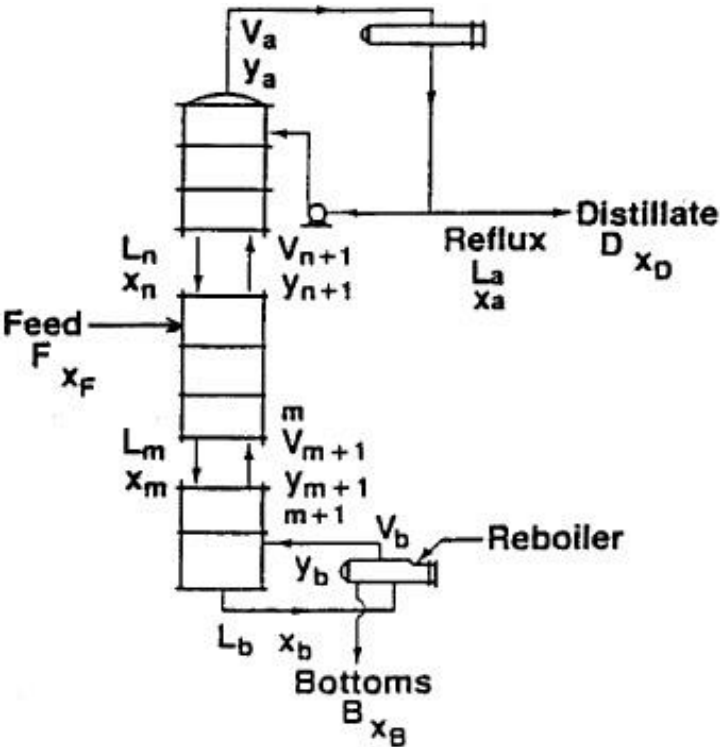
DISTILLATION/ABSORPTION COLUMN DESIGN

Distillation Control



DISTILLATION/ABSORPTION COLUMN DESIGN

BINARY SYSTEMS: Use McCabe Thiele



Given x_B and $x_D \rightarrow$ calculate RR, #trays, Feed tray, D, B

Given x_D and RR (for fixed #trays and feed tray) $\rightarrow x_B, D, B$

Given 2 operating values (for fixed #trays and feed tray) \rightarrow the rest

\rightarrow Design

\rightarrow Operations

\rightarrow Operations

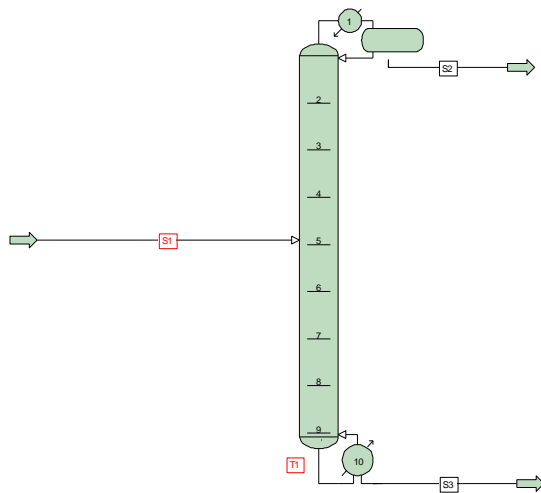


DISTILLATION/ABSORPTION COLUMN DESIGN

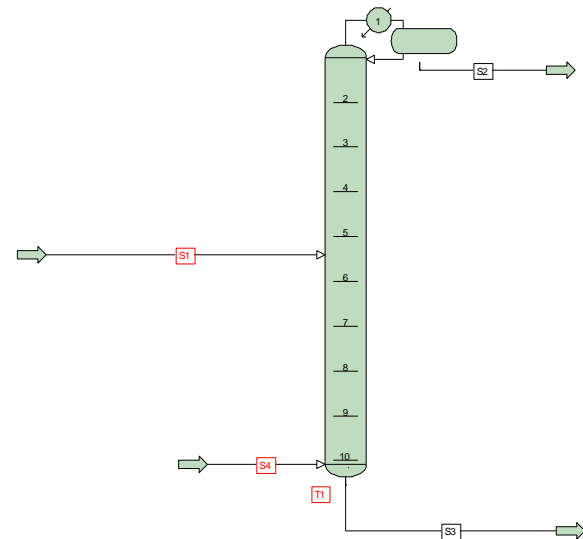
MULTICOMPONENT SYSTEMS : Use Computers!!!

Degree of Freedom= Number of unknowns – Number of equations

One per each condenser, reboiler or draw.



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1



DISTILLATION/ABSORPTION COLUMN DESIGN

MULTICOMPONENT SYSTEMS : Use Simulators

Case 1: You know number of trays and feed tray location

You need to fix variables or add equations.

- Add Equations (The easiest), e.g. Reflux ratio and Recovery ratio
- Fix variables, e.g. Compositions, temperatures, flows, etc.

THIS WAS COVERED IN SEPARATIONS



DISTILLATION/ABSORPTION COLUMN DESIGN

MULTICOMPONENT SYSTEMS :

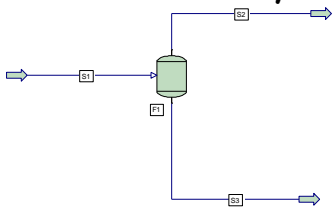
Case 2: You know nothing, not even the number of trays needed.

Use Fenske-Underwood Gilliland (see Separation Class Material) to get an idea

$$N = \frac{\log \left[\left(\frac{x_d}{1-x_d} \right) \left(\frac{1-x_b}{x_b} \right) \right]}{\log \alpha_{avg}} \quad \text{Simulators have this shortcut}$$

.... or if you are too lazy use the simulator as follows

1. Do not try blindly specs and number of trays. it won't work most of the time.
2. If you have many components do not include them all at the beginning. Start with a few of the most abundant components.
3. Put an adiabatic flash first. if the feed is not two phase at the desired pressure, use an isothermal flash. Change the temperature until you get some separation in the direction you want.



To do this list the components in increasing boiling point and determine key components. Light key goes mostly to the top. Heavy key goes mostly to bottom.

Continues in next slide...



DISTILLATION/ABSORPTION COLUMN DESIGN

MULTICOMPONENT SYSTEMS : Use Pro II

Case 2: You know nothing, not even the number of trays needed.

Continued...

4. Replace the flash by a three plates column, with similar specs as those given by the flash outlet streams. It should not be a big problem to get it.
5. Add the components that are missing. Do it slowly, increasing their concentration until you reach the desired values.
6. Keep tightening the specs and increasing the number of plates accordingly, so that you meet the separation you want.

